Review Article

Features and Services of Well-designed Hospital Information Systems: A Review Study

Masoomeh Nouri Tahneh [1], Hamid Moghaddasi [1], Azam Sadat Hosseini [1], Farkhondeh Asadi [1*]

[1] Department of Health Information Technology and Management, School of Allied Medical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

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Correspondence
Farkhondeh Asadi
Email:asadifar@sbmu.ac.ir

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Abstract

Context: Hospitals are large information organizations with the main goal of providing high-quality, integrated, and cost-effective healthcare. This goal is more easily realized through well-designed Hospital Information Systems [HIS].

Evidence Acquisition: In this narrative review study, 98 articles were extracted from Science Direct, PubMed, and Google Scholar databases using "Hospital Information System" keyword. The articles were published between 1980 and 2018. After examining the quality of the articles in terms of research design and references, 41 articles remained for analysis. Relevant e-books and print books were also examined, and the features and services of HIS were investigated.

Results: For HIS, seven features, namely the coverage of different types of data, integration of subsystems, having an enterprise metamodel, communication with other information systems, coverage of hospital units, adherence to standards, and connectivity to digital instruments were obtained. Moreover, 18 services of patient management, economic management and cost reduction, legal management of data, treatment management, administrative management, presenting information based on policies, clinical decision support, managerial-administrative decision support, educational support, research support, electronic medical record generation, text mining, encoding, documentation quality improvement, medical support, resource utilization management, personnel management, and warehouse management were determined.

Conclusions: To evaluate HIS, it is necessary to determine its features and services. Based on the features and services of HIS, its evaluation tool has been developed in this study.

Keywords: Hospital Information System, Metamodel, Electronic Medical Record, Text Mining

1. Context

The main goal of healthcare organizations is to provide high-quality, integrated, and cost-effective healthcare services [1]. Health care involves different people, all of whom need to share patient information [2]. Hospital Information Systems [HIS] provide appropriate information and knowledge at the right time and place to authorized people in an effective and usable

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manner [3]. Such a system includes the newest software solutions tailored to the standards, processes, and challenges of specific healthcare industries [4]. HIS is in charge of patient care and economic management [5]. The advantages of HIS implementation includes the creation of comprehensive treatment systems, promotion of patient safety, financial management, and acceleration of Electronic Health Record [EHR] generation [6]. For HIS to meet the hospital's information needs, it should be well designed and, for this, it should have specific features and services. Accordingly, the present study aimed to examine the features and services of well-designed HIS.

2. Evidence Collection

Various studies have been conducted on the features and services of HIS.

As Hadidi et al. [1981] put it, selection of HIS constituents requires careful examination. Major services resulting from precise selection of HIS components include saving time and human resource, more effective and efficient use of other hospital resources, and improving the quality of patient care [7].

Hubner-Bloder and Ammenwerth [2009] noted that HIS should support hospital information and offer appropriate data and information at the right time and place in an effective and usable manner to authorized individuals. HIS consists of information processing activities as well as human and technical information processing components, its main responsibility being supporting high-quality and cost-effective care for patients [3].

According to Vegoda [1987], HIS consists of applications for admission, discharge, and transfer; nursing; laboratory; pharmacy; radiology; other ancillaries [recording the orders, reporting the results, equipment management, worklist generation]; nutrition; operating room; health records; materials management; administrative management; and other items such as physiological monitoring, data management, biomedical engineering management, and doctors' office management. This system should not only be integrated, but also be able to punctually present accurate information to the entire hospital via a cost-effective method to pave the way for precise and quick decision-making and cost reduction [8].

Ball et al. [1991] reported the results of the international conference "Towards New Hospital Information Systems" held by the International Association of Medical Informatics in 1988. It was concluded in this conference that HIS has the following requirements:

HIS is supposed to process all hospital information. There should be integrity among internal hospital systems which need to easily communicate with those outside the hospital [third-party payers, doctors' office, etc.] as well. The following seven requirements, confirmed by Cohen, were also pointed out as the major objectives of HIS:

- A databank should be created to generate continuous and integrated computerized health records for all the patient care-related data, always offering the data directly to healthcare providers.
- The patient data should be exchanged with all the clinical and administrative units of hospitals in all the affiliated healthcare centers.
- It must support all medical activities [e.g. recording the orders, reporting the results, recording patient history and examination results, and reporting counseling and procedures] and exchange patient data with all the authorized healthcare specialists through user-friendly terminals.
- It should support medical and

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administrative decisions.
- It should create and store files for the administrative and business-related affairs of the hospital.
- It should help ensure quality, accreditation, rules, and regulations.
- It should support research and education [9].

Based on Collen's [1991] definition, HIS creates computerized patient records and exchanges patient data and health records with healthcare specialists in all the medical subsystems, including supportive medical services [radiology, laboratory, etc.].

This system creates a databank that can meet the medical and health-related research needs. It also supports the education of the employees and patients; meets the requirements of data confidentiality, security, integrity, and legality; and supports medical decisions and quality assurance procedures [10].

Hammonds [1994] showed that HIS includes a set of subsystems. Each department has its own subsystem through which it performs its duties and communicates with the other subsystems. One of the differences between HIS and separate subsystems is that the former creates an integrated database and establishes communication among the subsystems. The main subsystems include admission, discharge, and transfer; accounting management; recording the orders; reporting the results; management of departments and specialized functions programs of laboratory, radiology, pharmacy, nursing, health records, nutrition, and counseling. This system covers all types of data, including characters, images, waves, maps, digital photos, videos, speech, and audio. HIS should also meet the needs of the patients. The patient support includes security, privacy, confidentiality for patient data, education and awareness-raising, welfare and reminding the appointments, admission, tests, and other health-related items [11].

Spyrou et al. [2002] reported that in healthcare informatics, a defined standard specifies an agreed-upon method of data collection, storage, and transfer among computerized systems. Standards are essential to complex healthcare settings; healthcare providers should collect and store data in a standard manner so that they can be integrated [12].

According to Leiner et al. [2003], HIS services include the provision of different types of data, especially patient data; offering medical knowledge about diseases and healthcare interventions; provision of information about the quality of patient care and hospital functions and costs; and offering education and research services in teaching hospitals [13].

According to Haux [2004], HIS aims to provide patient care, including patient management, by taking into account the hospital's economic management as well as legal and other requirements. This system should cover different hospital units, such as the wards; outpatient units; service units, including diagnostic [e.g. clinical laboratory, radiology], therapeutic [e.g. operating room], and other units [e.g. pharmacy, medical record archives, library, blood bank]; hospital management units [e.g. general management, patient management and accounting, technology, economy, human resource supply, and medical unit and ward management]; and educational, research, and administrative affairs.

In the future architecture of HIS, communication with the information systems of other healthcare organizations should be taken into account, so that they can have access to or exchange patient-related and other data between centers [14].

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Özogul et al. [2009] came to the conclusion that HIS should provide healthcare providers with services such as strategic services, resource and supply chain planning, common care support, patient management, and comprehensive support. HIS enhances efficiency, reduces risks, and controls costs. Citing Ransom et al. [2004], they also noted that HIS supports an infrastructure that provides rapid and high-quality services and promotes sustained financial development [4].

Yucel et al. [2011] argued that HIS is an integrated system designed for administrative, financial, and patient care management. This system records all the services provided to the patients, the prescribed medication, and bills, and can connect to the insurance organization. The advantages of implementing HIS include promotion of patient safety, creation of comprehensive medical systems, financial management, and quick access to the EHR [6].

According to Cline et al. [2013], a complete HIS contains EHR, radiological picture archiving and communication system [PACS], radiologic information system, laboratory information system, pharmacy information system, critical care system, administrative and financial systems, human resource management system, patient scheduling and management, treatment documentation, visit and discharge summaries, statistics, and reports. They noted that, overall, HIS automatizes the patient-related administrative and medical affairs, being able to eliminate paper-based processes [15].

3. Results

Based on the literature, HIS has seven components, and its services comprise 18 components [Tables 1 and 2].

Jayawardena [2014] maintained that HIS helps quality assurance via different methods such as primary care quality assessment, quality indices monitoring, patient care evaluation support, and simultaneous and continuous auditing of the care process by using reminders or decision supports [16].

Moghaddasi [2018] showed that a combination of metamodels as a basic HIS architecture is required for designing and using HIS. In addition to managerial information systems to support decision-makers in administrative and medical units, each of the two major sections of HIS, i.e. the administrative information system and the clinical information system, has a decision-making support system. The cooperation between the two systems is a fundamental principle. In addition, the use of dashboard software for utilizing different levels of management in administration and treatment facilitates the implementation of management and improves decision-making efficiency. The existence of a encoding system, providing EHR, and connecting all digital devices, especially point-of-care [POC] systems, are the other specifications of HIS [17].

Saluvan and Ozonoff [2018] cited the 2003 IOM report based on which there are eight major categories of services for HIS: provision of health information, result management, computerized physician order entry [CPOE], decision support, electronic communication and connectivity, patient and administrative processes' support, and population health reporting and management [18].

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4. Conclusion

In the articles examined, various definitions have been proposed for HIS. Nevertheless, HIS in its practical sense is introduced as a metamodel. The metamodel defines the overall architecture of the system. Diverse metamodels have been introduced so far, the most complete of which is the enterprise metamodel. A combination of metmodels as a basic HIS architecture is required for its designing and using [20]. In the present study, an enterprise metamodel was proposed as it contains all types of metamodels and covers all aspects of the architecture of HIS.

Given the significance of patient-oriented care, diagnosis, and treatment beyond institutional boundaries recently highlighted, these advancements should be included in the future architecture of HIS [14]. Since one of the priorities for continuous provision of care is compatible and integrated information sharing [65], communication should be established both among internal hospital systems and systems outside the hospital [9]. In the first place, communication between the subsystems of HIS should be established to integrate the data at the hospital level. In the more advanced stages, to create smart hospitals, HIS should communicate with other information systems. This way, patient information can be integrated at a wider level and, therefore, be easily and quickly retrieved. High-quality services can also be provided without wasting time and other resources.

Communication among subsystems and different systems requires the use of defined standards [26]. The data with a standard format based on accepted definitions should be collected, stored, and integrated [12].

Wager et al. [2009] divided the standards into three main categories: classification, vocabulary and terminology; data exchange; and EHR content standards [71]. According to Spyrou et al. [2002], healthcare informatics standards can be divided into five groups of terminology, structure and content, messaging, integration, and security standards [12]. In the present study, the standards of interoperability and safety were divided into five categories: EHR structure and content, information terminology, data classification, data security, and data exchange.

HIS is designed to meet all the information needs of the hospital [3] and is the main repository of all the patient-related information [80]. There are different types of data [text, image, audio], all of which should be effectively managed [19]. This not only helps mechanize all the activities but also obviates the need for paper-based processes.

The ability to connect all digital devices, especially POC systems, in the design of HIS is essential for transferring and using the data [20]. Limited references have noted these two features; however, they have been regarded as important features of HIS due to their significance in data integration and access to the original data. It is necessary to have access to original data because there could be differences in interpretation and reporting, and if there is access to original data, better decisions can be made.

One of the key features of HIS is electronic medical record generation. Yet, the content of electronic medical record should be specified at the standard level [20]. It should also be able to record patient data as free coded text [81]. To ensure information integration, electronic medical record should be able to communicate in inpatient and outpatient referrals. In addition, a summary of the electronic medical record

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should be automatically generated so that the important clinical history of the patients can be accessed upon each referral.
Ensuring a reliable and timely diagnosis is a major challenge because human memory is prone to lapses, various diseases can occur, and there are medical complexities resulting from miscommunication [79]; consequently, decision support is a feature of HIS. Of course, the decision support system is not limited to medical information, covering the administrative information system as well, and these two systems should interact [20]. Decision support has certain requirements. For instance, HIS should record data in the coded form to enable smart data monitoring and processing. It should also be able to communicate with electronic data sources. Based on the references examined, decision support systems cannot replace people; rather, they function as counselors while people remain in charge of making the final decision.

Therefore, HIS plays a decisive role in hospital management, and its appropriate design requires the precise identification of a hospital's information needs. Since the features and services of HIS reflect the hospital's information needs, one can help promote the quality of HIS by specifying these items. As indices of HIS design, development, and evaluation; these features and services can serve as a common communication tool for all those involved with HIS. That is to say, HIS can be designed, developed, and evaluated based on these indices. Eventually, if need be, HIS can be standardized considering the determined features and services.

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Conflict of interest

The authors declare no conflict of interest.

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Tables:

The features of well-designed HIS			Frequency	Reference
Covering all types of data [text, audio, image]			3	[8], [11], [19]
Subsystems integration			14	[1], [8], [10], [11], [12], [20], [21]20, [22], [23], [24], [25], [26], [27], [28]
Having an enterprise metamodel			1	[20]
Communicating with other information systems			5	[11], [14], [22], [28], [29]
Covering the hospital units	Setting appointments and admission		2	[8], [14]
	Discharge			
	Health information management			
	Medical wards			
	Emergency department			
	Clinic			
	Operating room			
	Radiology			
	Laboratory			
	Pharmacy			
	Nutrition			
	Accounting			
	Logistics			
	Warehouse [medical equipment, medication, general]			
	Administrative affairs			
	Human resources			
Adherence to interoperability and security standards	EHR structure and content standards	HL7 HER Functional Model	4	[30], [31], [32], [33]
		ASTM E 31	2	[34], [35]
		ASTM E 1384	2	[31], [36]
		CCD	3	[31], [37], [38]
		Open EHR	4	[39], [40], [41], [42]
		EHR com	1	[43]
		ISO/CEN 13606	2	[39], [42]
		MML	1	[42]
	Information terminology Medical	SNOMED CT	16	[2], [4], [13], [30], [33], [41], [44], [45], [46], [47], [48], [49], [50], [51], [52], [53]
		UMLS	12	[2], [13], [30], [40], [44], [47], [48], [51], [52], [53], [54], [55]
		CPT	9	[30], [33], [34], [40], [44], [46], [54], [56], [57]

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	Nursing	NANDA	4	[40], [44], [50], [54]
	Medicinal	Rx Norm	4	[30], [33], [44], [58]
	Laboratory	LOINC	9	[30], [33], [34], [39], [44], [46], [53], [54], [59]
Data classification standards	Medical diagnosis	ICD-11	1	[41]
		ICD-10	11	[2], [13], [33], [34], [40], [41], [44], [49], [51], [54], [60]
		ICD-O	2	[13], [56]
		ICF	1	[13]
		DRG	6	[2], [30], [44], [50], [56], [60]
		DSM	3	[34], [44], [56]
	Nursing	NOC	2	[50], [59]
	Medicinal	NDC	2	[34], [44]
		ATC	3	[41], [44], [56]
	Procedures	ICHI	1	[41]
		HCPCS	4	[21], [34], [46], [54]
		ICD-9 CM	7	[13], [30], [34], [40], [44], [54], [61]
		ICPC	2	[44], [62]
		ICPM	3	[13], [51], [56]
		ICNP	1	[44]
		NIC	2	[44], [50]
Data security standards		HIPAA	10	[31], [33], [34], [39], [46], [51], [58], [63], [64], [65]
		ISO/IEC 27000	3	[35], [66], [67]
		ASTM E 31	2	[68], [69]
Data exchange standards		HL7	21	[2], [12], [14], [22], [30], [32], [38], [39], [44], [45], [46], [49], [51], [53], [54], [57], [58], [59], [60], [62], [70]
		DICOM	22	[21], [23], [30], [31], [32], [33], [37], [40], [41], [43], [44], [46], [49], [51], [53], [54], [57], [58], [59], [60], [70], [71]
		ANSI X 12 N	4	[21], [30], [33], [44]
		IEEE 1037	4	[31], [39], [44], [72]
		CEN/TC 251	5	[12], [35], [53], [58], [73]
		ISO/TC 215	4	[35], [58], [67], [74]
		XML	11	[20], [21], [29], [46], [48], [50], [53], [59], [60], [62], [74]
		ASTM E 1238	2	[44], [54]
		NCPDP	3	[30], [44], [46]
		ISO/CEN 13606	2	[39], [42]
Connectivity to digital devices, including POC systems			2	[9], [20]

Table 1. The features of well-designed HIS

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The services of well-designed HIS	Frequency	Reference
Patient management	6	[4], [8], [11], [14], [15], [25]
Economic management and cost reduction	18	[1], [2], [3], [4], [5], [7], [10], [11], [14], [15], [16], [18], [21], [25] , [75], [76], [77], [78]
Legal management of data	6	[1], [3], [10], [14], [16], [27]
Treatment management	6	[7], [10], [16], [20], [18], [25]
Administrative management	8	[1], [4], [5], [10], [16], [20], [18], [25]
Provision of information based on internal and external disclosure policies and the level of access	8	[3], [8], [9], [11], [16], [19], [27], [77]
Medical decision support	10	[9], [10], [11], [14], [16], [20], [18], [21], [23], [77]
Managerial-administrative decision support	3	[20], [18], [27]
Educational support	3	[9], [14], [54]
Research support	5	[9], [10], [14], [54], [75]
Electronic medical record generation	11	[7], [9], [10], [11], [13], [15], [20], [19], [23], [25], [26]
Text mining	5	[10], [61], [79], [80], [81]
Encoding	2	[20], [81]
Documentation quality improvement	2	[16], [25]
Medical support [care quality improvement, error reduction, patient safety enhancement]	15	[1], [3], [4], [5], [7], [8], [10], [11], [16], [18], [23], [25], [27], [77], [78]
Resource utilization management	5	[7], [10], [15], [23], [27]
Personnel management	5	[4], [7], [10], [23], [27]
Warehouse management	2	[21], [27]

Table 2. The services of well-designed HIS

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